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Selecting safer building products in practice

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ABSTRACT

In recent years the green building movement has focused increased attention on chemical hazards in building products and the need to select safer alternatives. This paper describes a number of tools available to architects and other building professionals and explores the product evaluation process behind one resource, BuildingGreen's GreenSpec directory, as a window into the imperfect reality of alternatives assessment in the building design field.

1. Introduction

The modern "green building" movement dates back to the energy crisis of the 1970s, but it wasn't until the late 1980s that human health aspects of the built environment became a major consideration. In 1973 the American Institute of Architects (AIA) formed a Committee on Energy and many in the building industry began to focus on making buildings more energy efficient (Building Design and Construction, 2003). This single-minded focus on energy backfired, as reduced air exchange from tighter seals worsened indoor air quality resulting in "sick building syndrome." After chemical offgassing from building products was implicated in a prominent case at EPA headquarters in 1988 (Malin, 2006), concern over harmful volatile organic compound (VOC) emissions became a part of the green building movement. Since its first pilot version in 1998, The US Green Building Council (USGBC)'s LEED rating system has included indoor environmental quality as one of its categories of impact, with credit available for selecting products with low VOC emissions.

Over time the US green building movement has taken an increasingly broad view of what concerns are included in the designer's purview. However, despite other well-established material-based hazards in buildings such as lead and asbestos (Campbell et al., 2010; Rabin, 2008), and emerging concerns such as phthalates, halogenated flame retardants, and others (Hotchkiss, 2008; Spengler and Adamkiewicz, 2009; Weschler, 2009) more comprehensive attention to chemical hazards in building materials is a relatively recent phenomenon and not yet widespread within the green building movement. The healthcare sector was the first to focus more broadly on chemical hazards in the built environment. The efforts of Healthcare Without Harm, The Global Health and Safety Network, Kaiser Permanente, and many others (Horrigan, 2005; Kaplan et al., 2009), raised the level of awareness about these issues among building professionals, owners, and product manufacturers. Chemical hazard concerns are now becoming part of the wider green building movement as evidenced by the materials red list within the Living Building Challenge (Went, 2009). This deeper attention is not yet the norm. LEED2009 still does not include a credit for reducing chemicals of concern, although there is now a pilot credit for eliminating Persistent Bioaccumulative Toxins (PBTs) from products (USGBC, 2010).

Building professionals who take on the task of reducing health concerns from buildings, face many challenges in actually selecting safer building materials. Among those challenges:

- Choosing what level of priority and attention to give to minimizing chemical hazards relative to other life-cycle impacts of buildings and building materials.
- Determining what is in a product (let alone what hazards may be emitted during a product's full life-cycle),
- Determining what chemicals are to be avoided, possibly by establishing a "red-list."

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- Finding safer (red-list chemical free) products—that work, and are available, and are affordable
- Assessing whether a product free of a red-listed chemical may simply contain a lesser-known hazard.

While some building professionals are making an effort to seek out products with the lowest life-cycle environmental impact, life-cycle information is frequently unavailable. Also, LCA tools have elicited criticism (Henrik et al., 2007) for not adequately accounting for chemical hazards (Niederl-Schmidinger and Narodoslawsky, 2008). There is a growing array of information available on chemical hazards, and selecting safer alternatives. However much of this target manufacturers or other sectors and are not of practical use for designers and other building professionals. Understanding chemical hazard issues, screening products, selecting, and learning to use alternatives is a complex and time-consuming process. Few architects, interior designers or specifiers have the time or expertise to engage in toxicology debates and the design community has had little guidance for how to practically implement the precautionary principle in addressing emerging chemical concerns.

Until recently, there were few resources available for designers seeking to integrate concerns regarding chemical hazards into their practices. The set of tools described below provide a roadmap for integrating chemical hazard issues into a building professional's product-selection process.

2. Tools for hazard assessment

2.1. Red list approach in use today

Some design firms have taken a minimal-compromise approach for hazards of high concern. For these firms, establishing a Red List of hazards to avoid in product selection is a critical first step in minimizing these hazards. "Red lists," which define a set of chemicals to avoid, are increasingly common and make a bold statement about chemicals that pose concerns regardless of how or where they are used. This approach contrasts with the risk analysis approach used by many manufacturers, which presumes that risk corresponds directly to the level of exposure as well as the nature of the hazard. For PBTs—and for toxins like endocrine disruptors where research shows a nontraditional dose-response (Hotchkiss, 2008)—the extra caution seems warranted.

Red lists should be wielded with care, however. New or lesser-known substitutes for a red-listed chemical are not necessarily safer. In addition, a red-list approach does not consider factors such as available alternatives and any environmental tradeoffs associated with them. Nonetheless, red lists like the Living Building Challenge Red-List and the Perkins+Will Precautionary List, below, can be a useful way to focus effort.

2.1.1. The living building challenge red-list

The Living Building Challenge originally launched in 2006, with v2.0 launched in November 2009 (International Living Building Institute, 2010), challenges design teams to achieve a "deep-green" ideal building, far beyond what is required by the LEED green building rating system (Lee and Burnett, 2008). LBC has seven performance areas with a total of twenty mandatory 'Imperatives,' such as Net Zero Energy, Net Zero Water, and Car Free Living. LBC's imperatives in the Materials performance area include the Red List: avoiding all products that contain any of the 14 red-listed hazardous chemicals (such as lead) or chemical families (such as halogenated flame retardants).

The creators of the LBC list are clear that not all hazards of concern are covered—or implementation would become infeasible. They have focused attention on key known and emerging hazards found in building products, seeing the LBC as a tool to raise awareness with manufacturers and ultimately transform the market. As it is, many project teams working toward the LBC have found the red-list among the most difficult and time-consuming aspects of the Challenge, particularly in conjunction with another Materials Imperative, "Appropriate Sourcing," that steers design teams toward regionally sourced materials. Numerous exceptions have been made to reflect the realities of the market. Design teams must write a manufacturer about their concerns with a product's constituent hazards before they can be granted an exception in the LBC (Went, 2009).

2.1.2. The Perkins+Will Precautionary List

The design firm Perkins+Will announced their Precautionary List of chemicals in the Fall of 2009 (Perkins+Will, 2010). Perkins+Will has begun using this list internally as a guide to help them remove products with listed chemicals from their material libraries and projects – at least where alternatives are available. Perkins+Will developed the Precautionary List with participation of its specification group, which has now folded the content of the List into its Masterspec requirements.

The Precautionary List Terms of Use make its intent clear: "We believe that it is appropriate to apply the precautionary principle when selecting and specifying products and materials" and that the evolving list is developed "with the understanding that we live in a world without scientific certainty." The list covers emerging concerns like neuro, endocrine, and reproductive toxicants, listing chemicals like Bisphenol-A and phthalates commonly found in building materials.

The online list is freely available and browsable by chemical name, CSI MasterFormat division (a system that categorizes building products), health effect, or environmental category (such as indoor air quality or ozone depletion). Each chemical listing includes where it is found in building products, a general list of alternatives, and a rationale including references for the chemical's appearance on the list. Created by practicing designers for practicing designers, the list is uniquely tailored to industry needs and provides inspiration to other firms. Perkins+Will's perspective is that substantive change requires this kind of sharing between firms.

2.2. Moving beyond the red list to safer chemical properties

The LBC, Perkins+Will, and Pharos red-lists (described below) do not prevent the substitution of red-listed chemicals with lesser-known hazards that are likely to be similarly harmful. By basing the screening on chemical properties, the Green Screen and Basta system described below are taking the next vital step in procuring truly safer products.

2.2.1. The Green Screen

The Green Screen (Cleaner Production Action, 2010) is designed for use by manufacturers, but is included here because it points the way forward from a red-list approach to a green-chemistry approach. The Green Screen evaluates a chemical (and its known and predicted breakdown products) against 11 hazardous properties (e.g., carcinogenicity), and defines detailed hazard criteria for four benchmarks toward safer chemicals. There are other sector-specific (EPEAT, 2010)(Clean Gredients, 2010) efforts along these lines, however the Green Screen is the first general, public, and transparent system. This opens the way for knowledge of safer chemicals evaluated through the Green Screen to be made available to those evaluating products.

2.2.2. The Basta System

The Swedish Basta System (BASTA, 2010) uses a set of criteria for hazardous properties similar to the Green Screen approach, but

goes a step further by listing products that meet safer criteria. Manufacturers with products in the BASTA System self certify by signing an agreement stating that they know the chemical composition of the product, have the competency to determine the properties of constituents, confirm that the product satisfies the requirements – and can provide full documentation if a random audit is performed. The BASTA requirements are based on the EU's REACH (Registration, Evaluation and Authorization of Chemicals) legislation (BASTA, 2010). BASTA provides an example of the kind of system that could be easily applied by designers while providing a degree of assurance that products are actually safer and do not simply contain lesser-known hazards.

Unfortunately BASTA and the GreenScreen are of limited practical use to US designers today because they don't relate directly to evaluation of products available in the US. A large US purchaser could conceivably make use of the BASTA system by developing a trade partnership in Sweden to select and import BASTA products where hazard concerns are considered significant enough to warrant such an approach. Similarly a large purchaser could use the Green Screen as a specification tool, in place of or addition to a chemical red-list, by requiring major suppliers to verify that product constituents have less-hazardous properties as defined by a specific Green Screen level, essentially creating an in-house database like BASTA. Neither of these approaches would be conceivable without significant purchasing power and resources to dedicate. This approach would also be made easier if the US regulatory framework for chemicals were to change to reflect a more precautionary orientation and require increased information on chemicals of concern along the lines of proposed Toxics Substances Control Act (TSCA) reform legislation and the EU's current REACH legislation.

2.3. Balancing toxicity with other concerns

Designers use the materials of a project to tell the 'story' of that project. The needs of a particular building project and the priorities, aesthetic, budget and values of the client drive the product selection process. Even for an environmentally focused client, aesthetics, cost, and performance are not to be compromised, and just within the set of environmental concerns, values and priorities vary by person and project. While an LCA practitioner might suggest a focus on the biggest life-cycle impacts, or a health advocate on high hazard concerns in product areas with the greatest room for improvement or impact, the designer's focus will vary depending on the project needs. For example indoor air quality and toxicity concerns might dominate for a healthcare facility, while embodied energy concerns might dominate for a model zero-energy home.

The LEED green building rating system acknowledges these varying priorities by, after a minimal number of prerequisites, basing the award (certified, silver, gold, platinum) solely on the total number of points achieved. This has led to criticisms that a LEED building, even a Platinum building, could conceivably (if not practically) be achieved without deep treatment of Energy for example, or any treatment of IAQ beyond the prerequisites (Wargo et al., 2010). Designers with a story to tell relating to reduced toxicity for a safe and healthy built environment frequently look beyond LEED to tools listed here for both recognition and guidance.

A few tools, such as the Pharos Project and the GreenSpec Product Guide (2010), provide information and guidance to help designers navigate toxicity in conjunction with other environmental priorities.

2.3.1. Pharos project

The Pharos Chemical and Material Library (Healthy Building Network, 2010) provides a comprehensive and searchable list of hazards. The library compiles a wide spectrum of government hazard lists, making them accessible to anyone seeking to understand whether a chemical present in a product is of high concern. Pharos does not currently include information on safe or untested chemicals that are not on an existing hazard list. Pharos provides a public and transparent alternative to proprietary lists such as that underlying the McDonough Braungart Design Chemistry Cradle to Cradle Protocol (MBDC, 2010).

Pharos also includes a small but growing list of products evaluated against five sets of criteria, including VOCs, user toxics, and manufacturing toxics. Pharos conducts a level of detailed investigation—even sleuthing out material patents—beyond what other product information resources provide. The Pharos Building Material Library is intended ultimately to provide comprehensive product analysis and ratings. Rather than developing a certification based on the best products in a given category, Pharos tries to define what an environmentally sustainable product should be—and compare existing products to that ideal. Pharos plans to ultimately evaluate materials across an additional 11 impact categories, such as embodied energy and water use, end of life toxicity, social justice, and habitat impact. Pharos does not aggregate impacts, leaving it up to the user to determine how to value (or weight) categories in comparing products.

2.3.2. GreenSpec Product Guide

The GreenSpec Product Guide (BuildingGreen, 2010) includes an independently screened directory of green building products across all product sectors. In selecting products, the GreenSpec editorial team reviews a wide range of life-cycle concerns including constituent chemical hazards. GreenSpec's aim is to balance pragmatism and precaution to create a product guide that is useful to designers who are specifying products today while helping steer the industry toward safer, more environmentally friendly products.

GreenSpec's guidance document "What Makes a Product Green" (Wilson, 2006) lays out the challenge:

> "The Holy Grail of the green building movement would be a database in which the life-cycle environmental impacts of different materials were fully quantified and the impacts weighted so that a designer could easily see which material was better from an environmental standpoint. Though efforts are afoot along these lines we are not even close to realizing that goal. Very often, we are comparing apples to oranges. We are trying to weigh, for example, the resource-extraction impacts of one product with the manufacturing impacts of another, and the indoor air quality impacts of a third.

The editorial process GreenSpec uses to evaluate concerns is illustrative of the process firms must go through in assessing products. Like a building professional or design firm librarian, GreenSpec must make product determinations based on available data—regardless of its quality or comprehensiveness—balancing both a wide range of life-cycle concerns (Wilson, 2006) and the availability of preferable alternatives. GreenSpec's treatment of hazards in building products varies along with the widely varying information on both a product and the context in which to evaluate it. Like other tools in this survey, GreenSpec takes a precautionary approach, considering emerging concerns on par with concerns for which the data is thoroughly established.

3. Product evaluation in practice – GreenSpec case study

No single tool yet provides an effective means to balance chemical issues against the wider set of life-cycle issues or adequately deals with the extent of incomplete information and uncertainty that remains. GreenSpec's pragmatic approach provides

a window into how to make reasonable decisions in that imperfect context, using whatever information and tools are available.

GreenSpec works to balance the breadth of concerns with alternatives assessment and a precautionary orientation. This balancing act weighs the need to drive market change by demanding safer and more environmentally responsible products with the immediate need of designers to specify quality products that are available now.

GreenSpec's approach is to:

- Use "life-cycle thinking" to focus attention on primary impacts for the product type;
- Assess constituent materials for special consideration when chemicals of concern are believed to be present;
- Subjectively weigh impacts against availability of alternatives and potential for market improvement to determine selection criteria for each product sector.

3.1. Using life-cycle thinking to focus attention on primary impacts for the product type

GreenSpec uses life-cycle thinking to focus on key criteria that drive impacts for a sector (Table 1), particularly where detailed life-cycle analysis is not available. Life-cycle concerns are categorized as follows (detailed in What Makes a Product Green):

- Products Made with Salvaged, Recycled, or Agricultural Waste Content
- Products That Conserve Natural Resources
- Products That Avoid Toxic or Other Emissions
- Products That Save Energy or Water
- Products That Contribute to a Safe, Healthy Built Environment

As better alternatives come to market and more information becomes available to differentiate individual products and assess environmental impacts across a product sector, the considerations for listing in GreenSpec become increasingly nuanced or may change. For example, in the past GreenSpec listed recycled cast iron effluent pipe as an alternative to PVC effluent pipe. When research came to light showing that cast iron effluent pipe production had more harmful human and environmental health effects than PVC, cast iron was also delisted. Detailed criteria are described in GreenSpec product sector overviews.

3.2. Assessing constituent materials for special consideration of chemicals of concern

In the GreenSpec process special attention is paid to constituents of high concern that can have a significant impact on human and environmental health, even at minute quantities (such as those slated for phase out by the EU or with characteristics of a chemical to "Avoid" according to the Green Screen). The challenge for both the GreenSpec review team and building professionals selecting products is that:

(a) many constituents are not listed on MSD sheets, particularly minor constituents or those with emerging hazard concerns not yet on the government's radar;
(b) little is known about impacts of the vast majority of chemicals; and
(c) viable product alternatives do not always exist.

Thus, GreenSpec focuses first on concerns that arise across a product sector (such as the use of the halogenated flame retardant HBCD in polystyrene)(Wilson, 2009), for which more investigative time can be spent, and secondarily on the composition of individual products where data are available and other life-cycle concerns are not an overriding consideration (such as for nonstructural interior finish). Depending on priorities for the category, GreenSpec may review MSD sheets; ask manufacturers for specific information about additives, binders, and finishes; request disclosure about "red-list" ingredients; or place on indefinite hold a borderline product until a manufacture is able to provide adequate proof of the safety of constituent materials. In short, the depth of the investigation into chemical concerns depends on available information, what other environmental concerns are significant, and what product alternatives exist.

3.3. Weigh impacts of concern with availability of alternatives and potential for market improvement to determine selection criteria for each product sector

GreenSpec uses qualitative editorial judgment to weigh the level of concern from constituents with the availability of alternatives and other environmental and health criteria that distinguish products within the category, to determine a balanced approach to the product sector and/or individual product selection. This "balance" can vary dramatically sector to sector (See Table 2 for examples).

3.3.1. Include most preferable alternatives

GreenSpec excludes individual products containing high hazard chemicals where feasible alternatives exist. Where there are available substitute products that are cost-effective and of comparable performance, only these alternatives are included in GreenSpec.

GreenSpec is also likely to describe or list "stretch alternatives," which are alternative materials, products, building designs, or code approaches, that may not be easily adopted, but can point industry

Table 1
Sector Priorities.

Product Type	Focus on	Approach to chemicals
1. Mechanical, Electrical, and Plumbing Systems	Efficient operation	These sectors have other top priorities. Chemical constituent concerns relevant to the product sector are addressed in selection criteria, but chemical constituents may not be reviewed for individual products.
2. Enclosures (windows, insulation, etc.)	Effective moisture and thermal protection	
3. Massive, Structural (concrete, steel, etc)	Embodied impact	
4. Interior Finish Non-structural Materials (plastics, composites)	Indoor emissions Embodied impact	Chemicals and emissions are top priority. Chemical constituents are reviewed for each product.

Table 2
Examples of GreenSpec's listing decision for specific sectors.

Listing Decision	Product Sectors
Include most preferable alternatives	Textiles (the product line from OEcotextiles has significantly reduced impact relative to the sector norm)
Include preferable alternatives, with caveats	Commercial Carpet (virtually all products on the market include fluorochemical treatments for stain resistance, raising health and environmental concerns)
Exclude all products, take an editorial stand	Electrical Wire (halogenated flame retardants and heavy metals) Polystyrene Insulation (HBCD flame retardant)

leaders and innovators toward products and practices that dramatically reduce environmental impact.

3.3.2. Include most preferable alternatives – with caveats

There are frequently no impact-free products or easy alternatives for a product sector. Thus, GreenSpec often includes products that, while environmentally preferable to the majority of products in the sector, contain chemicals of concern or other clear negative attributes. In these cases, GreenSpec uses section and product description to highlight both the benefits relative to standard practice and any remaining concerns—with the intent of driving change within the industry.

3.3.3. Take an editorial stand – exclude all products

In special cases, GreenSpec sets high standards that exclude all or nearly all products in a sector, taking an editorial stand designed to push the market toward safer products. This typically takes place when it is believed that a key concern (usually a chemical constituent) is not being adequately considered by the industry, and that designers can be supported in selecting the best option without GreenSpec actually listing products. This may be because there is no other key differentiating factors or because the best alternatives are easily obtained commodity products.

For example, after research into the hazards of building wire (Malin, 2006), GreenSpec announced that it would only list electrical wire and cable that was free of halogens and heavy metals. While products that meet this requirement are now available, at the time there was no wiring available to the US commercial building industry that met these criteria. GreenSpec's judgment was that there was no other key environmentally differentiating factor for building wire and that it was important to raise awareness about the issue by making a bold statement about what was needed from the industry.

4. Conclusion

In the absence of a regulatory structure for chemicals that is adequately protective of human and environmental health, the green building community is increasingly addressing chemical hazards in building products directly through their product procurement.

A set of new tools is emerging that helps building professionals make more informed decisions regarding chemical hazards. While not yet widely adopted, these tools provide a palette of options to facilitate decision making and outline the path for future development. For many in the industry, the first major step on the path to safer building products has been the establishment and use of a red-list of chemical constituents to avoid when making product selections. This red-list approach, used by the Living Building Challenge and the Perkins+Will Precautionary List, signals to product manufacturers that there is demand for safer products. However, the absence of comprehensive information on chemical properties and chemical safety can lead to substitution of widely recognized hazards with related, but lesser-known hazards. The Green Screen and the BASTA system go beyond this red-list approach to ensure that any constituent chemicals exhibit safer properties.

Advances in chemical assessment are vital, as are advances in life-cycle analysis—and efforts to better integrate hazard assessment into LCA are still needed. In practice, however, the building industry is still a long way from having adequate information to be able to make use of the best available assessment methodologies, and even where *information* is available, truly preferable (safe, high-performing, and cost-effective) alternatives may not be.

Pharos, in its fully developed form, could shine a beacon toward those truly preferable alternatives, and provide a platform for comprehensive review for each area of concern. Ultimately, however, a decision must be made balancing impacts. Aggregated LCA scores are based on a predetermined weighting of environmental impacts. Pharos refuses to aggregate impacts. GreenSpec's approach is to use the best available data, a life-cycle approach, and educated subjective judgment to weigh considerations. GreenSpec's process provides insight for balancing pragmatism and precaution in making product selection decisions despite inevitably limited time and information. This involves the following: using life-cycle thinking to prioritize the research effort and weigh impacts of concern; asking for key information even if you aren't likely to get it; always remaining aware of what could not be factored into the analysis and update thinking based on new information; making one's priorities clear to the market through whatever means possible; and always remembering that ultimately a selection must be made from the available options. In the end, it comes down to the human ability to weigh dissimilar attributes and establish a preference—comparing apples to oranges. This is a weakness, but also a strength; most of all it is a window into the messy reality of product selection in practice in the inevitable absence of perfect information.

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